Farmers' Response and their Adaptation Strategies to Climate Change in Mafeteng District, Lesotho

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Farmers' Response and their Adaptation Strategies to Climate Change in Mafeteng District, Lesotho

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Abstract

Climate change has moved from being a hypothesis to being a reality. Changes in climatic conditions have resulted in profound impacts on agricultural production (crop yield and quality) and general livelihoods. This study assessed the response of farmers to climate change and its impact to their livelihoods and the potential of the three agricultural systems: viz. agro-forestry, conservation agriculture and conventional agriculture in Ts'akholo and Kolo communities in Mafeteng District as adaptation strategies to climate change. A representative sample was selected using a stratified sampling wherein members of a group were grouped into relatively homogeneous groups. The first stratum comprised of farmers that practice conventional farming and the second included farmers that practiced conservation agriculture and the third was farmers who practiced agro-forestry. A total of 120 farmers were selected for this study. Soil fertility analysis (Available P, Total N, Organic C, K, and Cation Exchange Capacity (CEC)) of the three agricultural systems were conducted. The results revealed that farmers in Ts'akholo and Kolo reported experiencing drought, sporadic and heavy rainfall periods, soil erosion, declining yield, pests and disease infestation, and short growing season and this has led to them developing their own adaptation/coping strategies to climate change. Some of the adaptation strategies include water harvesting technologies, conservation tillage, use of keyhole and trench gardens, agro-forestry and application of traditional medicine to control pests and diseases. The results indicated that soil fertility was found to be more in Conservation Agriculture than in Agroforestry and least in Conventional Agriculture. Farmers in the two areas have an urgent need for support from either the government or local NGO's in terms of improved seeds, inputs subsidies, trainings, information and knowledge sharing. This study has contributed to knowledge in the field of global environmental change and its relationship with agriculture, food security and general livelihoods, especially for the farmer in the two case-study areas as well as for policy makers in Lesotho.

1. Introduction

1.1 Background

Climate change in Sub-Saharan Africa is already impacting negatively on rain-fed agriculture and livestock systems. Kenya is already experiencing a number of hazards of climate change and climate variability (CVC) including more frequent droughts, prolonged dry spells, intense rainfall and flush floods, increased heat stress and disease outbreaks (IPCC, 2007). These climatic hazards are accompanied with more changes in the productivity of rain-fed crops and forage, reduced water availability and more widespread water shortages, changing severity and distribution of important human, livestock and crop diseases.

Dairy farming is a key component of livestock industry in Kenya and is dominated by Bos-taurus dairy breeds/genotypes (DBG) comprising Friesian, Ayrshire, Guernsey, Jersey and crosses amongst themselves (Muriuki et al., 2004). The DBG are raised in different agro-ecological zones under diverse production environments (PEDs) and are classified as vulnerable to poor feeding, heat load and disease incidences, which are projected to increase in frequency, intensity and magnitude with the increasing climate variability and change. The PEDs thus has both direct and indirect climate effects on DBG, which will adversely impact on the DBG performance and therefore limit their potential for providing food, nutrition, and income and job securities to the farmer (Muriuki et al., 2004). This does raise concerns of securing livelihoods for the farmer, creating the necessity to identify options and strategies for CVC adaptation by poor dairy farmers. Intervention measures are needed to contribute towards building adaptive capacity and resilience to climate variability in the short-term and climate change in the long-term, but are currently deficient in Kenya.

One approach to this problem is to characterize the PEDs in which a breed has been kept over time. Several technology practices and strategies have been suggested for mitigation and adaptation to CVC stress. However, breeding strategies targeted at improving their productivity have been applied uniformly disregarding the adaptability level of DBG. There is an urgent need for detailed performance assessment of DBGs under PEDs to guide the identification of appropriate breeding strategies that can help dairy farmers mitigate CVC and improve productivity and adaptation for secured livelihoods to the poor.

1.2 Cause and Effects

Increasing hazards of CVC are already being experienced and the increased scientific evidence for CVC has significantly raised the level of uncertainty about future climate conditions. The DBG are vulnerable to increasing hazards of CVC already being experienced in Kenya. The CVC hazards are accompanied with changes in disease outbreaks, forage productivity and, reduced water quantity and quality. These changes are projected to increase and DBG raised in diverse PEDs will likely suffer some impacts of increasing CVC since they are the most vulnerable to climate stresses and yet least adapted compared to Bos-indicus. These impacts of climatic stress on DBG performance have not been assessed and adaptations to offset these impacts have not been assessed in detail. Nevertheless, appropriate breeding strategies that can help dairy farmers stabilize production under changing CVC are unknown.

1.3 Objectives

1. To characterize the diverse production environments (PED) for dairy production by degree of vulnerability to climate variability (CVC).

2. To rank vulnerability of the dairy breeds/genotypes (DBG) to CVC in the identified PEDs based on farmers' experience.
3. To identify adaptive traits of importance to stresses of CVC in the specific PEDS.
4. To identify breeding strategies for DBG to CVC for improved productivity and adaptation.

1.4 Rationale

Comprehensive information on the PEDs of the DBG will; (a) facilitate better understanding of the potential impacts and consequences of CVC, (b) Increase industry capability to manage the implications of CVC, (c) Inform and engage industry stakeholders to improve understanding of CVC issues, (d) Facilitate better understanding of the likely impacts and opportunities associated with reducing and/or offsetting CVC for the dairy industry (e) enhance understanding needed of the likely impacts of CVC on the vulnerability of the DBG and (f) facilitate understanding of the resilience to current CVC and (g) enables the risks associated with longer-term CVC to be gauged, and appropriate actions set in place to increase or restore resilience where this is threatened. All these action combined contribute to securing livelihood assets for the poor.

2. Literature Review

2.1 The Concept of Climate Change

Climate change has moved from being a hypothesis to being a reality. This is substantiated by the fact that the global average surface temperature of the earth has increased by 0.6±0.20C since 1900 and it is likely that the rate and duration of the warming are greater than at any time in the past 1000 years (Intergovernmental Panel on Climate Change (IPCC), 2001a).

Climate change has been defined by IPCC (2007) as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forces, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. The UNFCCC (1992), on the other hand, defines climate change as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere, and which is an addition to natural variability that has been observed over comparable time periods. Climate, however, is only one factor within the dynamic earth system. Changes in the physical and biogeochemical environment, either caused naturally or influenced by human activities such as deforestation, fossil fuel consumption, urbanization, land reclamation, agricultural intensification, freshwater extraction, fisheries over-exploitation and waste production, contribute to global environmental change (GEC), (CCAFS, 2009).

Furthermore, CCAFS report of 2009 concludes that climate change on its own represents an immediate and unprecedented threat to the food security of hundreds of millions of people who depend on small-scale agriculture for their livelihoods. Food security is achieved when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life, (FAO, 1996). Changing climatic conditions are projected to affect food security from the local to global level. It is predicted that patterns of rainy season will be reduced, and the frequency and intensity of severe weather events such as floods, cyclones and hurricanes will increase. There will also be prolonged drought in some regions; and water shortages; and changes in the location and incidence of pest and disease outbreaks, (FAO, 2009).

2.2 Impacts of Climate change on farming and livelihoods in Lesotho

Climate change is taking place at a time of increasing demand for food, feed, fiber and fuel, and has the potential to irreversibly damage the natural resource base on which agriculture depends, (IAASTD, undated). Changes in carbon dioxide concentrations, temperature and rainfall will have an impact on plant cover and land use which will, in turn, substantially affect the behavior of water when it falls as rain, (Muller, 2007). Due to reduced adaptive capacity and higher climate vulnerability smallholder and subsistence farmers in developing countries may not be able to cope with climate change effectively and such conditions pressure to cultivate marginal land or adopt unsustainable cultivation practices is likely and may increase land degradation, water scarcity and endanger biodiversity. Degraded lands in the southern lowlands of Lesotho are more susceptible to climate change impacts such as increased temperature and more severe drought, (Ministry of Natural resources, 2000). Recorded land degradation problems in Lesotho include massive soil erosion that leads to gully formation and abandonment of land, loss of biodiversity, severe loss of vegetation and low agricultural production and productivity, (Ministry of Agriculture and Bureau of statistics, 1994). According to Mekbib et al, (2011) Lesotho is heavily influenced by a variety of competing weather systems, leaving the country prone to natural disasters, drought and desertification, loss of biological diversity and land degradation. In accordance with article 4 of the UNFCCC, 2000, these conditions indicate Lesotho as a country highly vulnerable to climate change. UNDP (2007) asserts that climate change threatens food security, livelihoods and economic prosperity with emphasis on the vulnerable members of the community (including the poor, HIV/AIDS patients and orphans).

2.3 Farmers Adaptation Strategies to Climate Change in Mafeteng, Lesotho

According to FAO (2009) climate change adaptation strategies are now a matter of urgency. It is necessary that climate change adaptation is not separated from other priorities but is integrated into development planning, programs and projects (World Bank, 2008). Responses aimed at adapting to climate change may, however, have negative consequences for food security, just as measures taken to increase food security may exacerbate climate change, (CCAFS, 2009).

2.3.1 Conservation Agriculture

Among the emerging adaptation strategies in Mafeteng district of Lesotho is the use of conservation agriculture system of farming, (International Federation of Red Cross and Red Crescent Societies, (2006)). As stated by Dumanski et al (2006) Conservation Agriculture is an application of modern agricultural technologies to improve production while concurrently protecting and enhancing the land resources on which production depends. Application of Conservation Agriculture promotes the concept of optimizing yields and profits while ensuring provision of local and global environmental benefits and services. Zero tillage, along with other soil conservation practices, is the cornerstone of Conservation Agriculture. In Mafeteng District, NGOs together with the Ministry of Agriculture and Food Security are promoting conservation agriculture for the purposes of minimizing soil erosion and increasing crop yield (International Federation of Red Cross and Red Crescent Societies (2006).

2.3.2 Agroforestry

The term agroforestry is often perceived in the narrow sense of intercropping food plants and trees. In a broader sense, it signifies any system that includes food, and/or fodder and wood production, (Ahlback, 1995). Agroforestry has also emerged as an important strategy to adapt to climate change in Mafeteng, (UNDP, 2011). It provides many opportunities for value added production and is also used as living contour hedges for erosion control, to conserve and enhance biodiversity, Dumanski et al, (2006). Agroforestry systems, even if not primarily designed for carbon sequestration, present a unique opportunity to sequester carbon from the atmosphere, (Verchot et al, undated). Carbon sequestration has been defined by the United Nations Framework Convention on Climate Change (UNFCCC), (2010) as the process of removing carbon from the atmosphere and depositing it in a reservoir. In this process atmospheric carbon dioxide is taken up by trees, grasses, and other plants through photosynthesis and stored as carbon in biomass (trunks, branches, foliage, and roots) and soils, (Center for Integrated Natural Resources and Agricultural Management and the Commonwealth Project, 2007). In essence, agroforestry core concerns include ecological and economic sustainability – resilience of environment and diversity of income. It is a system that blends production (food and income security at household- and community-level) with ecosystem services, (Jama, 2005).

2.3.3 Crop diversification

Crop diversity is large in the district (UNDP, 2010). It is well known amongst farmers that greater crop diversity and mixed farming (crops and livestock) offer considerable protection against farming risk, including climatic-related risk (FAO, 2011). In order to prevent total loss of crop production larger farming enterprises with a range of different crop types, or even cultivars of the same crop with differing drought or pest resistance traits are being implemented in Mafeteng District (International Federation of Red Cross and Red Crescent Societies, 2006).

2.3.4 Keyhole and Trench gardens

Moreover, keyhole and trench gardens are fast growing adaptation strategies to climate change in Mafeteng, (International Federation of Red Cross and Red Crescent Societies, 2006). The two systems were introduced to Lesotho by Care Lesotho, a local non-governmental organization. Keyhole and trench gardens have proven an effective way to grow vegetables year round in semi-arid climates because they nourish the soil and help it retain moisture (Weimer, 2008). The gardens reduce the labor required to produce food for the household (Weimer, 2008). This in turn helps households affected by chronic illness and HIV, and households headed by children or the elderly, which often have limited labor capacity. This is a good example of a low-cost adaptation practice which is also supported by local government and can be up-scaled to the national level (UNDP, 2010).

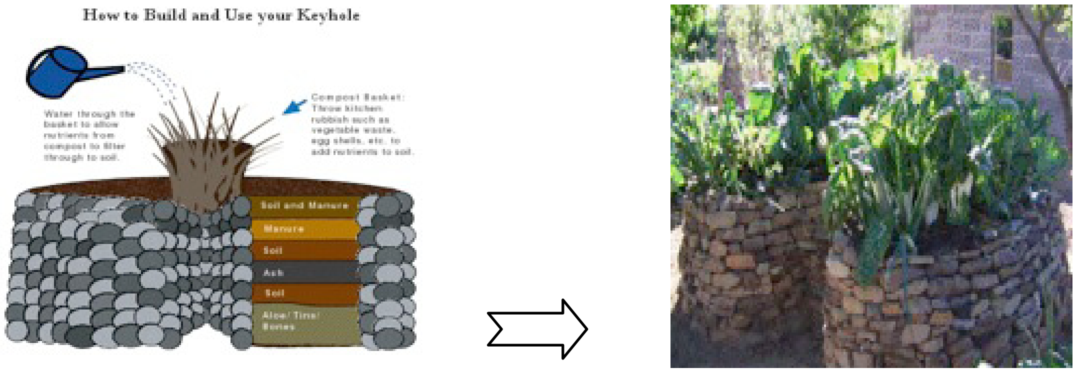

Figure 1: Keyhole garden

Keyhole gardens are easy to construct and advocate for use of locally available materials/ resources which include, among others; wood ash, manure, and aloe.
A lot of material are required for construction of Keyhole gardens but once constructed they are easy to maintain.

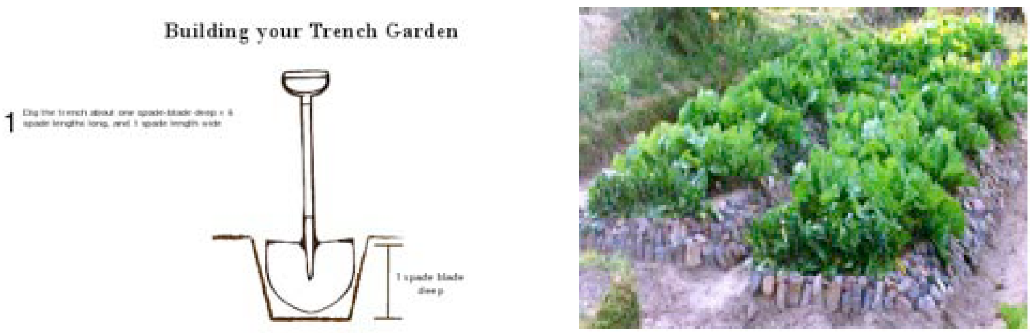

Figure 2: Trench garden

Trench gardens are dug into the ground (60 to 70cm deep) in the 1m x 2m space. Then a layer of aloe leaves, branches, cardboard or tin cans are placed at the bottom and the soil added on top. Dried grass or leaves are then added; lastly, a thin layer of soil is added and then a thick layer of manure.

2.4 Climate Change and Policy Formulation in Lesotho

Policy formulation for climate change poses a great challenge because it presents a problem of decision-making under uncertainty (Webster, 2002). Continued basic research on the climate system to reduce uncertainties is essential; however, policy-makers also need a way to assess the possible consequences of different decisions, including taking no action, within the context of known uncertainties, (Webster, 2003). While members of the scientific community and policy-makers are particularly concerned about adaptation to climate change, (Olmos, 2001) Bohle et al. (1994), on the other hand, believe that full understanding of current vulnerability is necessary for developing strategies to coping with future climate change.

Policy reform in Lesotho is dated as far back as the 1970s and early 1980s, although not directly related to climate change such policy reforms have been found to have a bearing on both mitigation and adaptation strategies. Such strategies include the promotion of renewable energies, the introduction of biogas projects, the introduction of an afforestation programme, water development, sanitation improvement, the formulation of new agricultural policies, environmental regulation, (Lesotho Meteorological Services, 2001). In developing countries such as Lesotho the youth and the vulnerable members of the community are more susceptible to the impacts of climate change and this condition is extreme among the poorest people, (IPCC, 2001).

3. Methodology

3.1 Population and Sample Selection

The target population for this study was all farmers in the two areas of Ts'akholo and Kolo in Mafeteng District. The areas were chosen for two reasons. Firstly, the areas are hardest hit by the impacts of global climate change in the district in terms of drought, soil erosion, and reduced crop yield. Secondly, the areas are conveniently accessible to the researchers. A representative sample was selected using a stratified sampling wherein members of a group were grouped into relatively homogeneous groups. The first stratum comprised of farmers that practice conventional farming and the second included farmers that practiced conservation agriculture and the third was farmers who practice agro-forestry. The total number of farmers who participated in the study was 120 farmers. Each village had 60 farmers and this comprised of 20 farmers for conventional, conservation and agroforestry, respectively.

3.2 Data Collection

Face to face interviews were conducted with individual farmers using a structured questionnaire. The interviews were conducted to determine the farmers' perceptions regarding impact of climate change on agricultural production and the technologies used by the farmers to adapt to climate change. For the purposes of validating the perceptions and views of farmers with scientific results/proof laboratory analysis of soil samples is mandatory. Soil samples were randomly selected across the fields of selected individual farmers. The soil samples at varying depths of about 0-10cm, 10-20cm, and 20-30cm were collected using auger. At each point, soil samples were collected into labeled plastic bags and then taken to the laboratory for analysis (Organic carbon, Available Phosphorus, Total Nitrogen, Potassium (K), Soil pH, Cation Exchange Capacity (CEC), and Textural class).

3.3 Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) plus 10 version. The Table below indicates aspect of data, data analysis and rationale:

Table 1: Data parameters

Aspect of Data	Statistics Used for Analysis	Rationale
Farmers' perceptions	Descriptive Statistics	Determine farmers' perceptions regarding impact of climate change on agricultural production and the technologies used by farmers to adapt to climate change.
Soil Properties	ANOVA	To determine if there were significant differences in soil properties of soil samples collected from field of farmers that practiced different farming techniques which include agroforestry, conservation agriculture and conventional agriculture

4. Results and Discussion

4.1 Demographic Characteristics of Farmers in the Study Area

Demographic characteristics considered in this study include, level of education, primary source of livelihood and the types of farming system used. These were used to get an overview of farmers' response with respect to their different social strata.

4.2 Climate Change Awareness

When asked whether they were aware of climate change and its impacts on both their agricultural production and livelihoods in general, almost all the respondents (93%) said yes (fig.3). This is an indication that climate change has indeed moved from being a hypothesis to being a reality. About half of them (50%) pointed out that media (especially radio) contributed to their awareness of climate change and its impacts. However, 29% of the responding farmers claim that their awareness is rooted in their own observation of the impacts of climate change, especially in their farming endeavor. It must be noted that the highest education level of respondents is high school and that their understanding of climate change is limited to their daily experiences and information from radio broadcast, hence, the need that media outreach through radio is enhanced so that more farmers can be reached and informed about climate change, its causes, consequences, mitigation and adaptive measures. When asked what they think should be done to spread climate change awareness, participants pointed out that both workshops and "pitsos" (public gatherings) can be organized to share information and knowledge between farmers and researchers (through extension services).

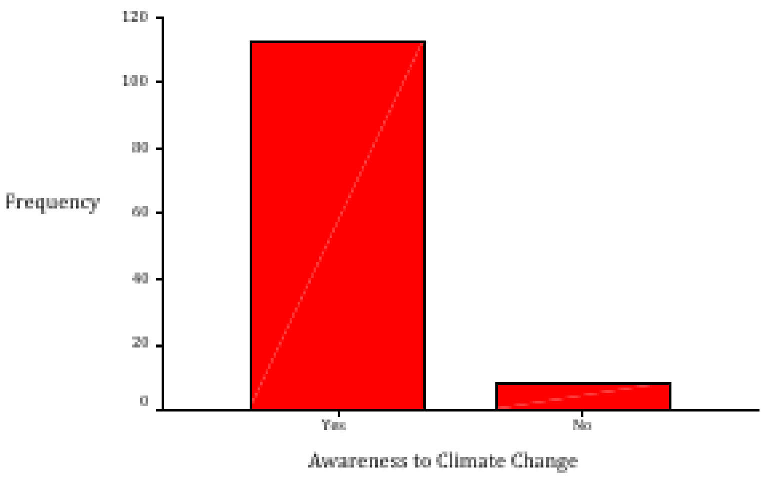

Figure 3: Climate Change Awareness to Farmers at Ts'akholo and Kolo

4.3 Impacts of Climate Change as reported by Farmers in Ts'akholo and Kolo

Interviewed farmers in both Ts'akholo and Kolo made it clear during the focus group discussion with the researchers that climate change affects them in their agricultural production. About 40% of them claimed reduction of crop yields as a result of climate change. Observation from farmers' fields at both Ts'akholo and Kolo revealed existing conditions of sheet and rill erosion. In this regard, 17% of the responding farmers in the two areas pointed out that soil erosion removed fertile surface soil resulting in soil fertility decline and consequently reduced crop yields. Some farmers (23%) said that they received below normal yields due to the impact of prolonged drought and heavy rainfall. This claim is supported by a vast amount of literature (examples include, Obioha, (2010) and, Ministry of Natural Resources, (2000)). Furthermore, the quality of the yield has been on the decline according to approximately 16% of the respondents at Ts'akholo and Kolo. The decline is attributed to low soil fertility, scorching sun on their crops, pests, drought, high variation and excessive rainfall. Lastly, a small portion of respondent (4%) claimed that climate change impact has resulted in shortened growing season. Through discussions with the farmers, it was revealed that famers receive late rainfall into the growing season and experience prolonged drought which hamper them from starting their cultivation ventures in time and by the time they start the growing season is already shortened. Figure 4 below gives a summary of climate change impacts based on the interviewed farmers at Ts'akholo and Kolo in Mafeteng District.

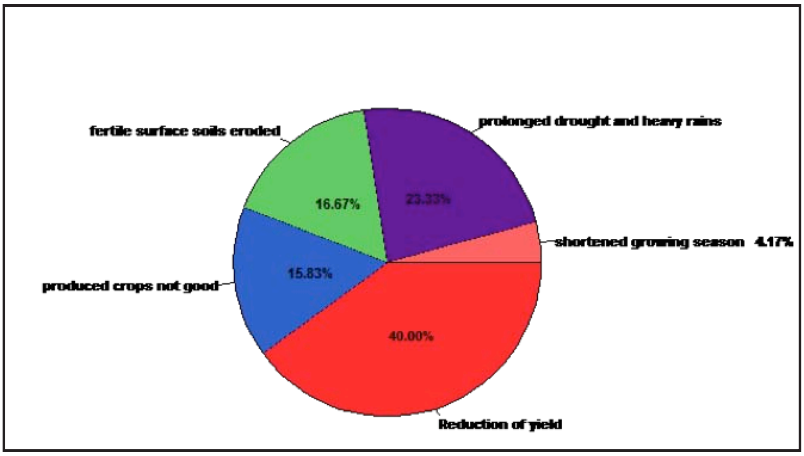

Figure 4: Impacts of Climate Change on Ts'akholo and Kolo

4.4 Farmers' Climate Change Adaptation Strategies in Ts'akholo and Kolo, Mafeteng

The majority of participating farmers' main source of livelihood is agriculture in one form or the other. About 60% of the respondents rely on crop production, 17% on both crop and livestock while only 3% rear livestock for their livelihoods. Only 12% and 8% had a full time job and remittances, respectively, which formed the basis of their livelihoods. In order to maintain their livelihoods in these unfavorable climatic conditions responding farmers at Ts'akholo and Kolo have come up with a number of adaptation strategies. One of the dominant adaptation strategies in the two areas is trench and keyhole gardens which the respondents said they adopted from World Vision Lesotho and Lesotho Red Cross Society (both are Non-governmental Organizations (NGO's)). The two NGO's conducted ''pitsos'' (community gatherings) where they shared their knowledge with community members and then conducted trainings for the local farmers and those who adopted the innovation were generously assisted and provided with essential resources such as shade nets and seeds.

Tree planting has become another adaptation strategy for farmers. When asked how trees were an adaptation strategy, respondents said that they use trees to rehabilitate gullies and integrate them with crops in their fields. Farmers said that fruit trees in their fields provided fruits for consumption and helped in controlling soil erosion (by providing ground cover with their canopy and leaves) and improve soil fertility through falling leaves. In addition, some farmers from Kolo diversified crops in order to counteract the effects of climate change. Their common practice is to plant maize, beans and pumpkins together or mix a variety of vegetables in their backyard.

Other farmers in the two areas said they apply their indigenous knowledge of traditional medicine to control pests and diseases while others adjusted their planting time in order to avoid some pests. They plant early August to overcome cut-worm or plant in the month of December when there is adequate rainfall. Those farmers who have livestock, especially cattle, use cow-dung instead of inorganic fertilizers when they plant to add fertility to the soil.

Being drought prone areas, respondents from the two areas made use of roof water harvesting technology to collect water and store it in stone built-tanks next to their houses while others practiced conservation agriculture which preserves moisture in their fields. The most fundamental principle of conservation agriculture is to till the soil to the minimum, maintain soil cover in the form of organic matter and to practice crop rotation. Some of the farmers said the practice helps not only in soil and water conservation but also in adding fertility to the soil. Fig. 5 shows adaptation strategies for Ts’akholo and Kolo farmers.

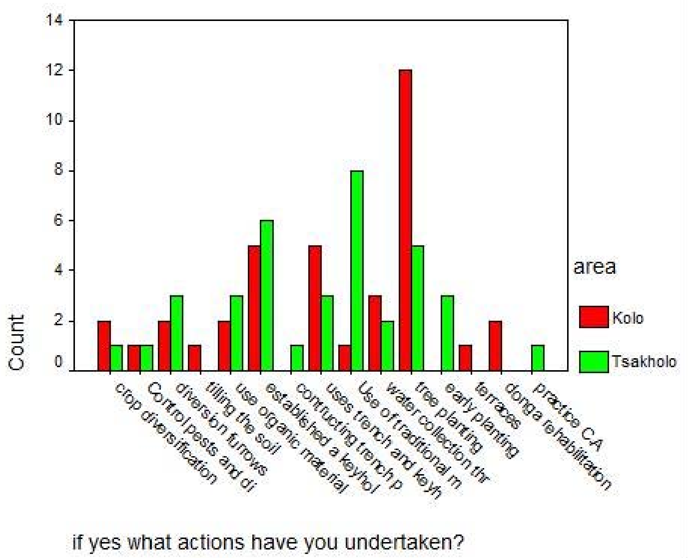

Figure 5: Ts’akholo and Kolo Farmers’ Adaptation Strategies

4.5 Comparison between the three Agricultural Systems

Participants were asked which agricultural system between agroforestry, conventional and conservation agriculture performed best in terms of yield. They acknowledged high yield from conservation agriculture and conventional agriculture. However, their response showed that they prefer conventional agriculture to agroforestry and conservation agriculture. Their main concern with agroforestry is that trees take a long time to grow. They claim that conservation agriculture, on the other hand, is labour intensive since they do not have its special equipment used for tilling the soil. Respondents are aware of the fact that conventional agriculture poses a risk of soil erosion and soil fertility decline. However, respondents were skeptical about shifting away from conventional agriculture due to its deep rooted entrenchment in their cultural practice.

Agroforestry system in Ts’akholo and Kolo is limited to fruit trees integration with crops in alley cropping pattern. There is no tree fallow (where trees are planted on a fallow field to enhance soil fertility and rehabilitate the soil) or other agroforestry systems that include livestock component such as in silvi-pasture. Those farmers that have already established agroforestry system said it has helped in harnessing soil erosion on their fields. Farmers seem not to have understanding or lack proper training on both agroforestry and conservation agriculture hence why the systems have not been practice adopted on a large scale like other innovations that have been brought by local NGO’s.

4.6 Soil Physicochemical Properties

In terms of soil fertility status for the three agricultural systems the following was analyzed: soil pH, organic carbon, available phosphorus, total nitrogen, exchangeable cations (potassium, sodium) and cation exchange capacity. Refer to Table 2 for full results of each agricultural system.

Table 2 : Mean separation of selected chemical characteristics for the three Agricultural Systems

Land Use	pH (H20)	pH (KCl)	Org C (%)	Av P Mg/100g)	NH4 ppm	K	Na	CEC cmol/kg
Agro-forestry	5.36	4.58	0.49	1.78	2.14	1.95	5.62	0.33
Convention Agriculture	5.57	4.68	0.51	1.60	2.15	2.02	17.2	0.38
Conservation Agriculture	5.73	4.93	1.54	1.93	2.08	4.86	8.64	0.40

Av P: Available Phosphorus, Org C: Organic Carbon, NH4: Ammonium Nitrate; CEC: Cation Exchange Capacity, Na: Sodium, K: Potassium

Soils in the three land uses recorded an acidic pH which is not ideal for some crops. Organic carbon was highest under conservation agriculture (1.54) when compared to convention agriculture (0.51) and agro-forestry (0.49). The cause for the high organic carbon under conservation agriculture is as a result of incorporating organic matter into the soil (which has been left over the soil after harvesting) or leaving it to cover the soil and not removing it. Organic carbon increases the fertility status of the soil. High amounts of available phosphorus were found under conservation agriculture (1.93) followed by agroforestry (1.78) and then conventional agriculture (1.60). Phosphorus is a nutrient highly essential to plants for their growth. Soils under conventional agriculture showed higher amounts of total nitrogen (2.15) and this can be attributed to fertilizer application. Agroforestry had (2.14) amounts of total nitrogen and conventional agriculture (2.08). Potassium was found to be in large quantities under conservation agriculture when compared to other agricultural systems. Furthermore, high amounts of salts (example, sodium (17.2)) were recorded in conventional agriculture and these results in sodic soils (this can be identified by sealing of soil pores and cracking soils). Overall, the order of nutrient content in the three systems is conservation agriculture> agroforestry>conventional agriculture.

5. Conclusion and Recommendations

Global climate change is a real phenomenon in Mafeteng district and this can be seen by a diverse number of climatic disasters that have hit the district in the past years and such include heavy rains leading to floods, strong winds that blow away buildings, droughts and desertification. Land degradation in the form of soil erosion and soil fertility decline is rampant in the district. However, land degradation has been exacerbated by bad practices such as burning of cow-dung and crop residues for energy as well as monoculture practices that result in declining soil fertility. Farmers in Ts'akholo and Kolo have experienced yield decline as a result of impacts of climate change. Given the growing extent of land degradation, drought and scarcity of rainfall in Mafeteng district and the low returns from agriculture clearly calls for more productive and robust methods to agriculture. Ts'akholo and Kolo areas have more undulating slopes than flat terrain and this means that conventional methods of agriculture (which tills the soil completely) will promote soil erosion, especially if terraces are not properly constructed and planting not done along the contour. On the contrary, agroforestry and conservation agriculture are well suited to all terrains because they promote soil cover and discourage easy movement of soil particles. The results from this study also indicate that soil fertility is high under conservation agriculture and agro-forestry than conventional agriculture and this automatically gives the two systems upper-hand over conventional agriculture. In addition, in-depth research needs to be done on the integration of conservation agriculture to agroforestry as adaptation strategy to climate change and then policy formulated out of such a study.

It can be recommended that farmers be given more support from both local NGO's and the government in terms of trainings, information and knowledge sharing, and other fundamental resources that they need in their farming systems. There is a need for policy formulation out of systems that promote ecosystem services such as agroforestry and conservation agriculture (such ecosystem services include harnessing soil erosion and promoting soil fertility). Farmers who practice environmentally friendly adaptation strategies can be paid or compensated (payment for ecosystem services, such as, carbon trading) for their initiative as a way of encouraging other farmers to do the same or they can be assisted with high-breed seeds (tolerant to drought and fast growing) and subsidized agricultural inputs from NGO's and the government.

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